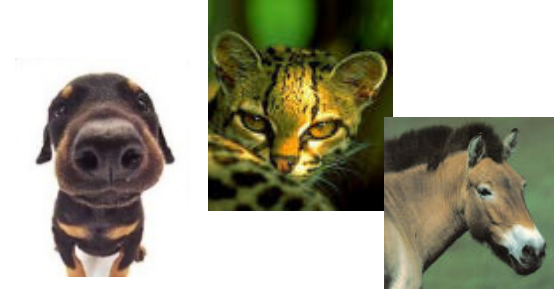


Marsupials – a controversy



SWS1 SWS2 MWS LWS



SWS1 ~~SWS2~~ ~~MWS~~ M/LWS



Marsupials???



SWS1 ~~SWS2~~ ~~MWS~~ M/LWS ↔ M/LWS



SWS1? SWS2? MWS? LWS?



Colour vision – marsupials

Dichromats?



Virginia opossum



Tammar wallaby

Trichromats?



fat-tailed dunnart



quenda

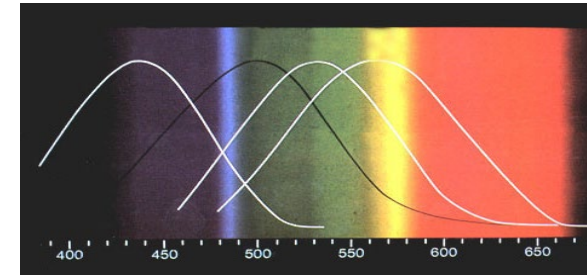


honey possum

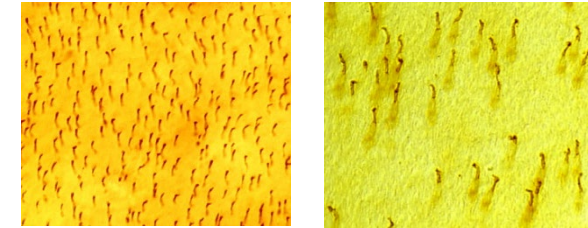


quokka

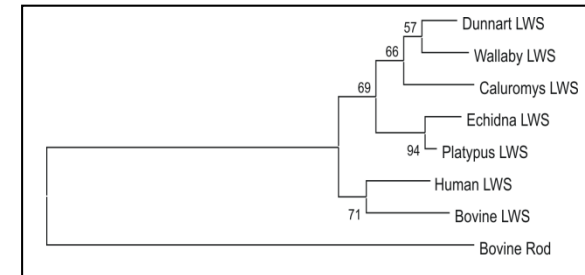
🦎 microspectrophotometry (MSP):
pigment absorbance



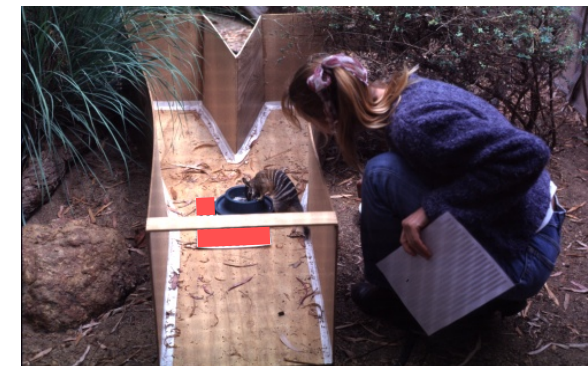
🦎 immunohistochemistry:
pigment presence + topography



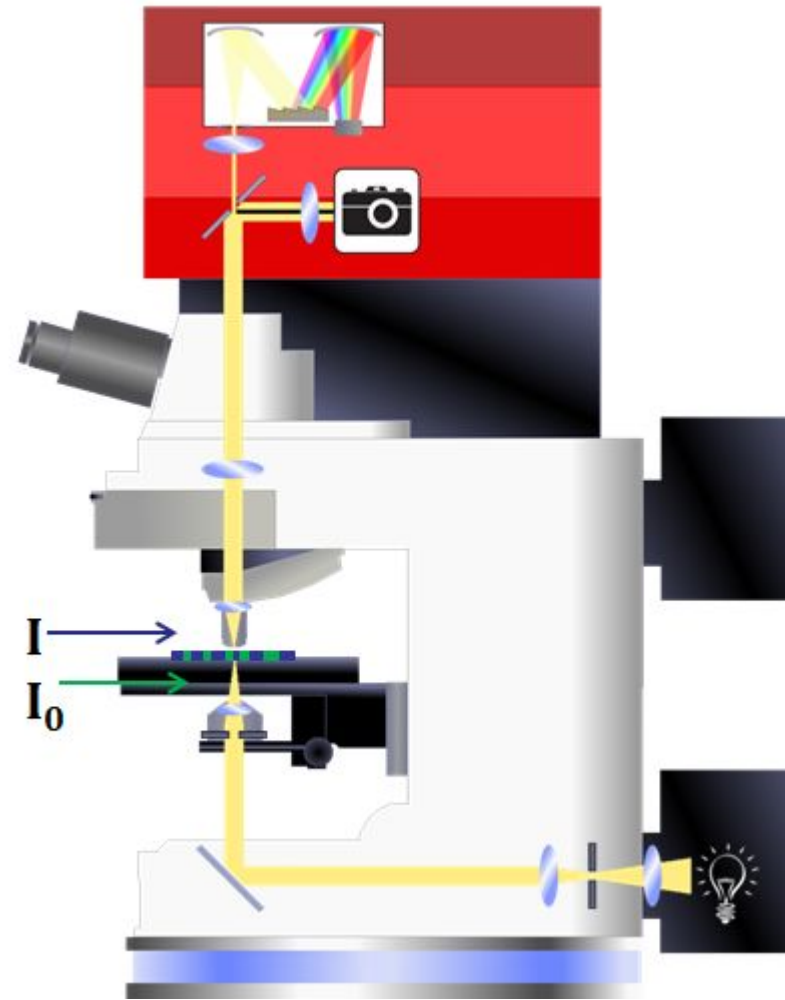
🦎 molecular biology: pigment
molecular structure + evolution



🦎 behaviour: use of colour vision



Microspectrophotometry

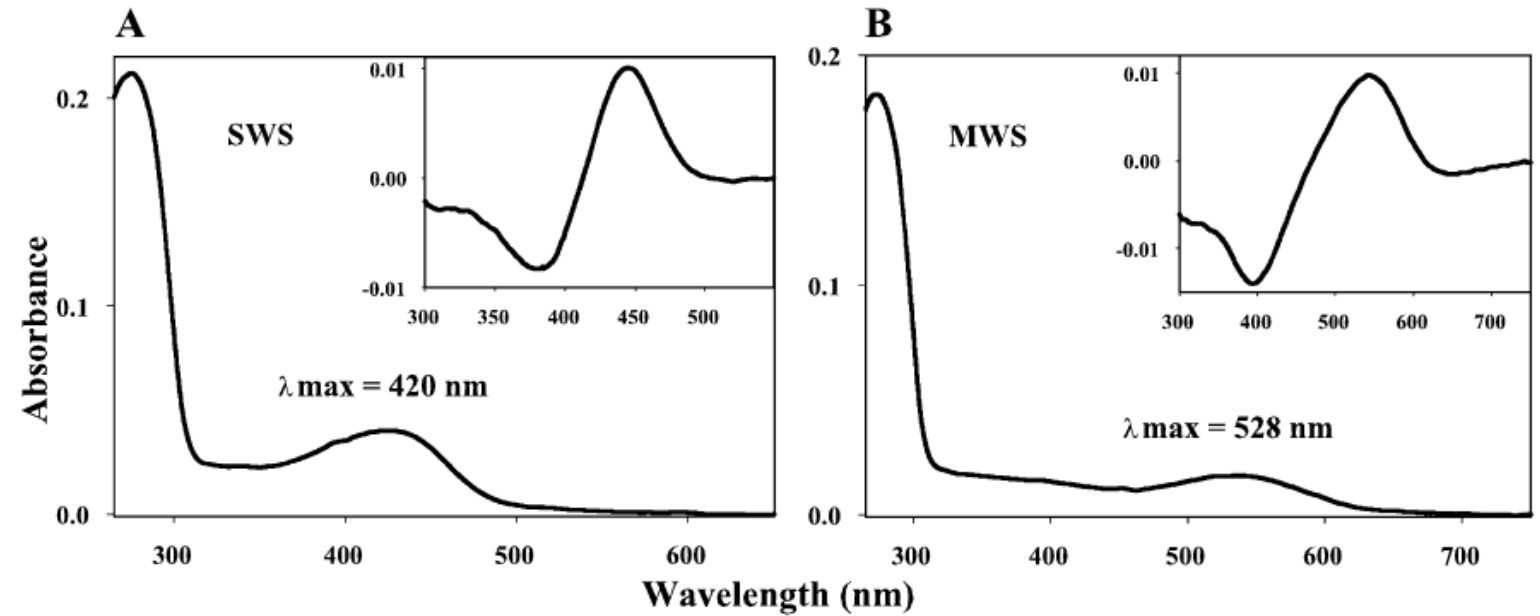


Measurement of wavelengths
absorbed by a single cell

Dichromats

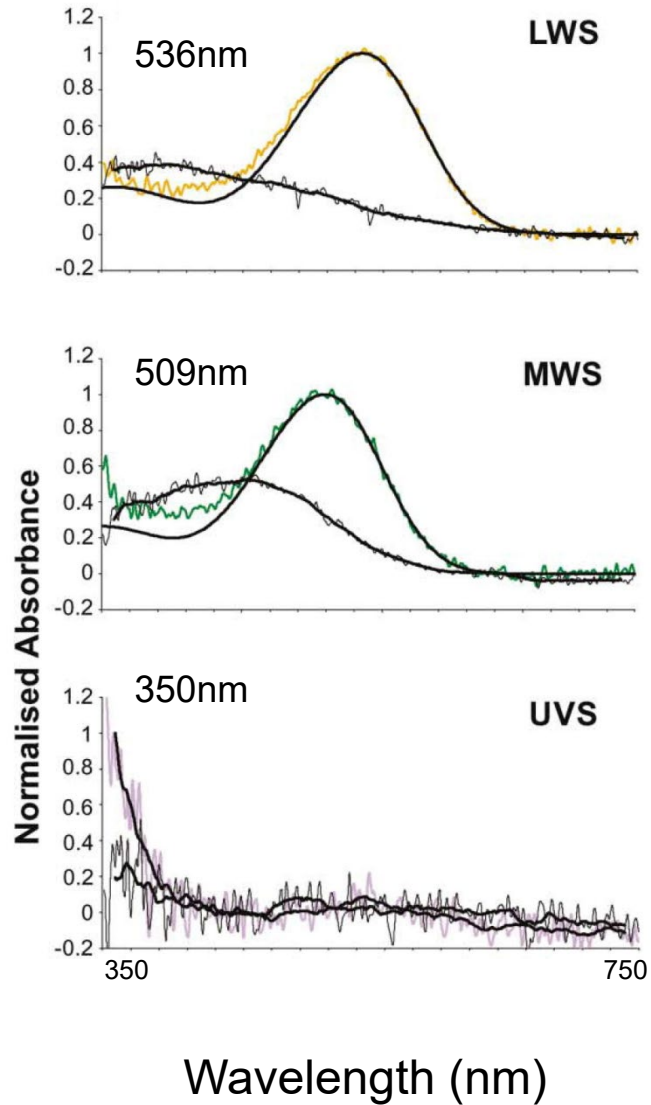


Tammar wallaby



The Cone Visual Pigments of an Australian Marsupial, the Tammar Wallaby (*Macropus eugenii*): Sequence, Spectral Tuning, and Evolution DOI: 10.1093/molbev/msg181

Trichomats



Fat-tailed
dunnart

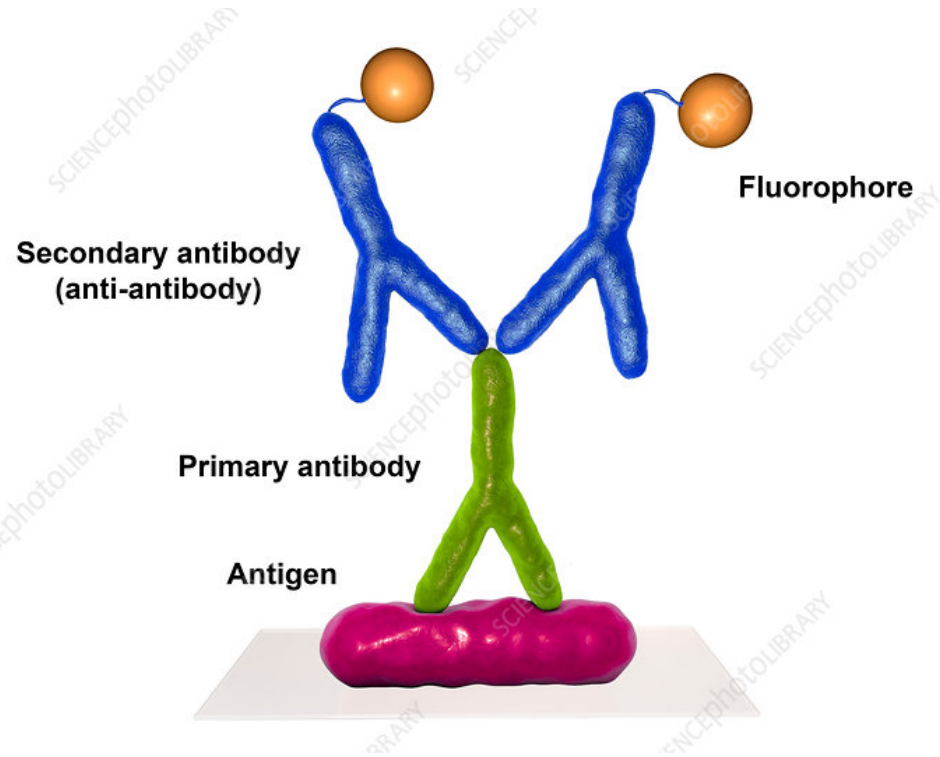


Honey
possum

Trichromacy in Australian Marsupials

DOI: [10.1016/s0960-9822\(02\)00772-8](https://doi.org/10.1016/s0960-9822(02)00772-8)

Immunohistochemistry

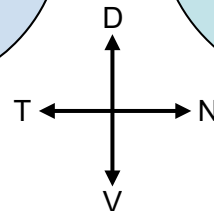
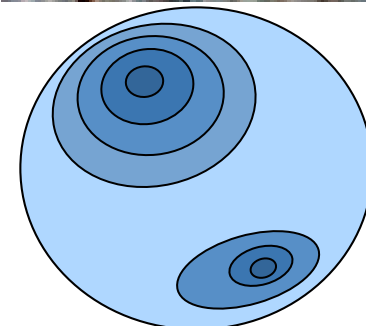
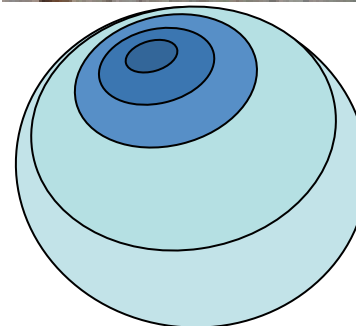
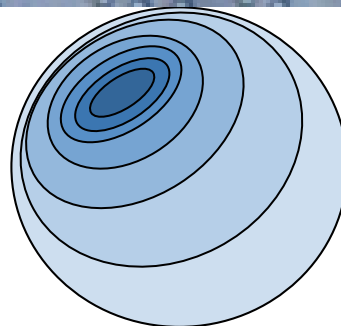
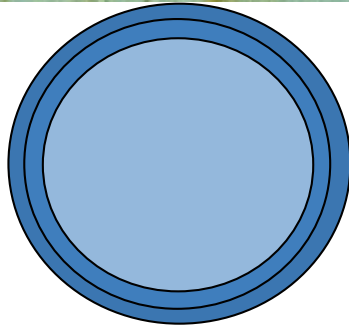
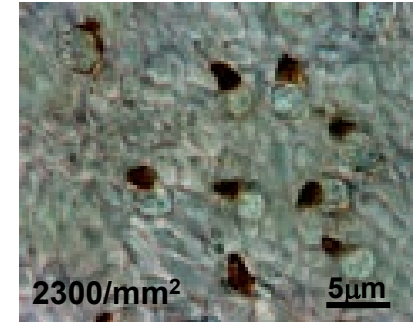
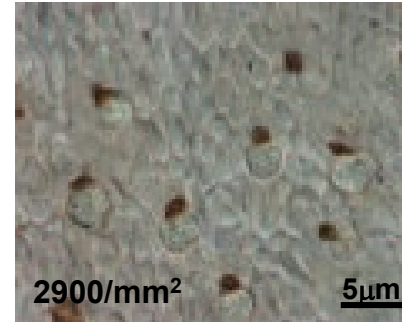
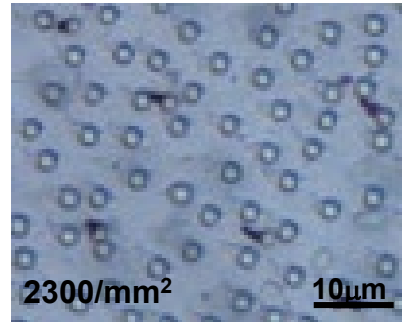
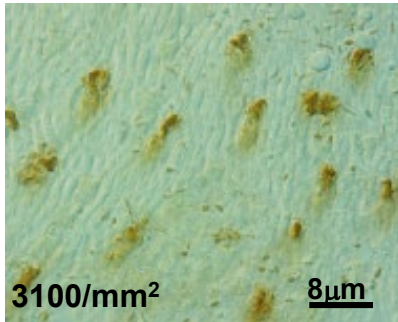


– inconclusive: antibodies are available only to SWS and LWS cones

But ~30% unlabelled cones in dunnart retina – mysterious 3rd opsin?

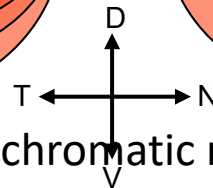
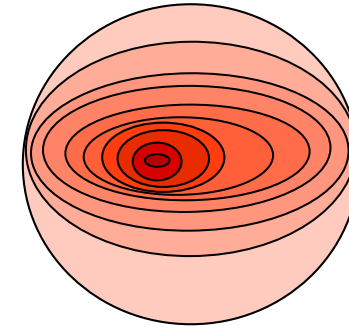
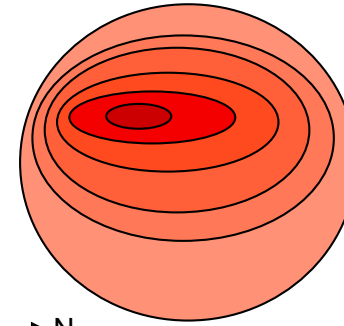
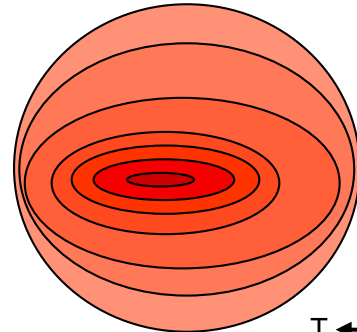
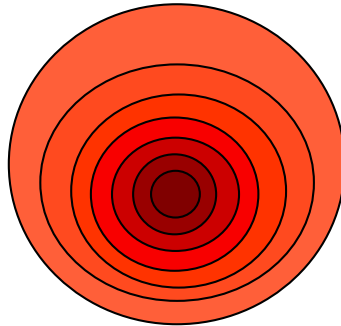
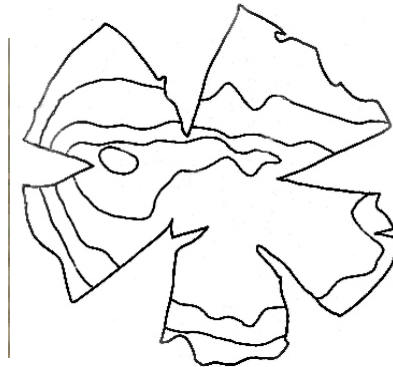
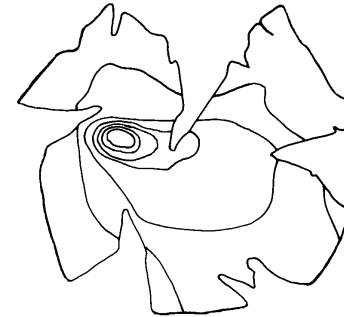
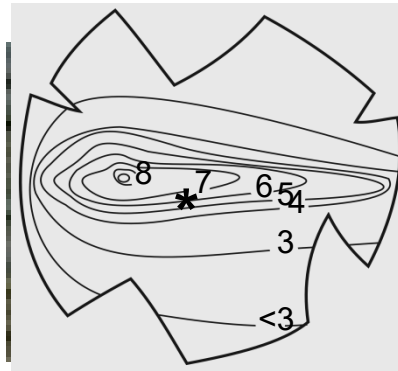
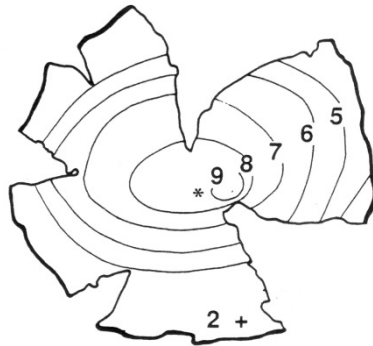
No unlabelled cones in tammar wallaby retina

Antibody to opsin SWS1 – JH455



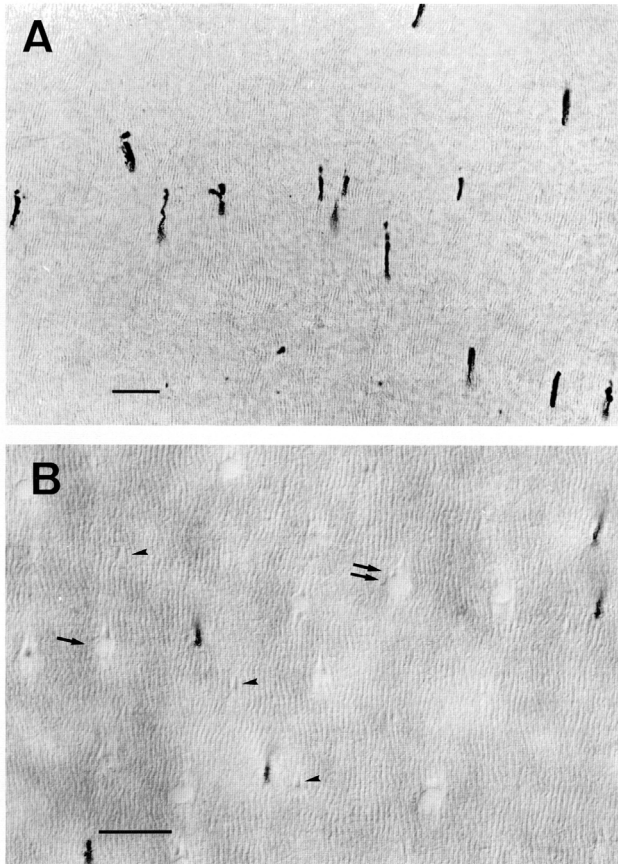
Topographies of retinal cone photoreceptors in two Australian marsupials. doi: 10.1017/s0952523803203096.

Antibody to opsin M/LWS – JH492

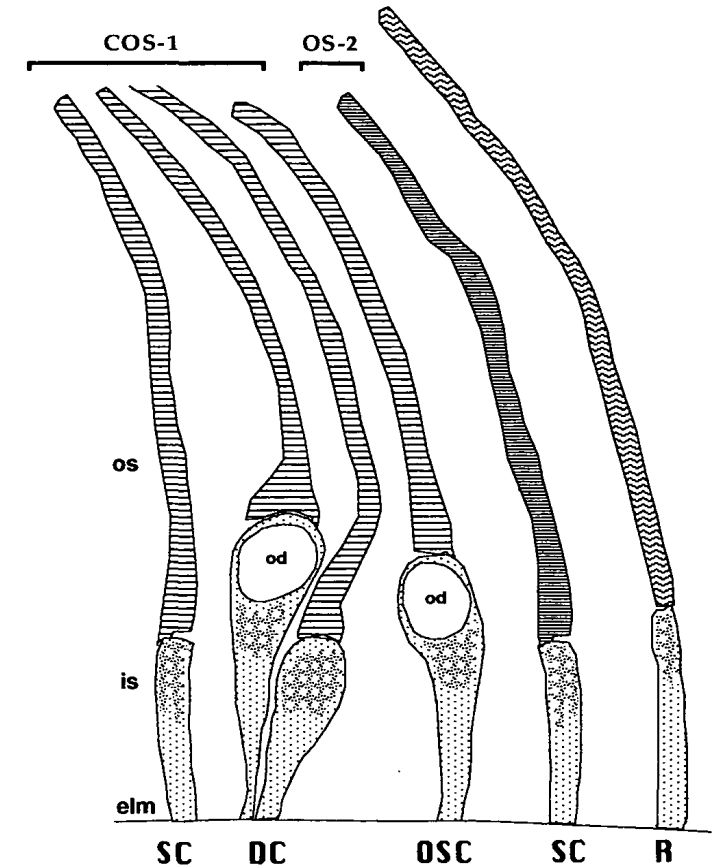
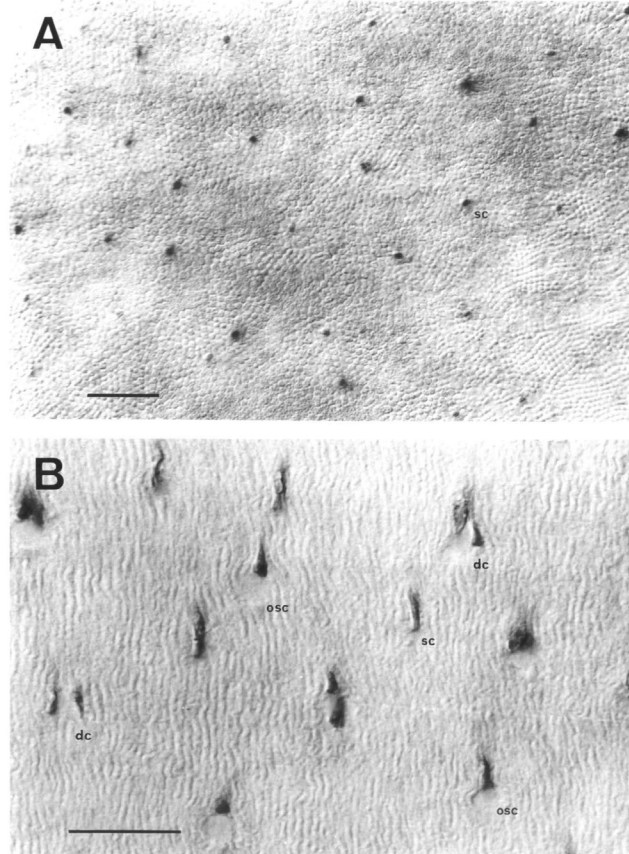


Cone topography and spectral sensitivity in two potentially trichromatic marsupials, the quokka (*Setonix brachyurus*) and quenda (*Isodon obesulus*) doi:10.1098/rspb.2004.3009.

Antibody OS2 = SWS



Antibody COS1 = LWS



Photoreceptors in a primitive mammal, the South American opossum, *Didelphis marsupialis aurita*: characterization with anti-opsin immunolabeling. doi: 10.1017/s0952523800009366.



Virginia opossum

DNA sequencing: dichromacy!

Table 2
Variation at Informative Amino Acid Sites of Mammalian SWS1 Pigments

Species	λ_{\max} (nm)	46	49	52	81	86	90	93	97	114	118
Wallaby	424	F	F	T	L	Y	S	T	S	G	S
Bovine	438	F	F	T	L	Y	S	I	T	A	C
Mouse	358	F	F	T	L	F	S	T	A	A	S
Human	424	T	L	F	F	L	S	P	A	G	T
Macaque	415	T	L	F	F	L	S	P	V	A	T

NOTE.—Residue numbers are according to the numbering system of bovine rhodopsin. Letters in bold represent amino acid residues that play a major role in spectral tuning.



Table 3
Variation at Amino Acid Sites That Contribute to Spectral Tuning of the Mammalian MWS and LWS Pigments

Species	λ_{\max} (nm)	180	197	277	285	308
Wallaby	530–531	A	H	F	A	A
Human	530	A	H	F	A	A
Deer	531	A	H	F	A	A
Mouse	508	A	Y	Y	T	S
Human	560	S	H	Y	T	A
Human	555	A	H	Y	T	A
Goat	553	A	H	Y	T	A
Horse	545	A	H	F	T	A

NOTE.—Residue numbers are according to those of human MWS.

No genetic evidence of a third cone in dunnart –

- Rod opsin in cones?
- A completely different pigment?

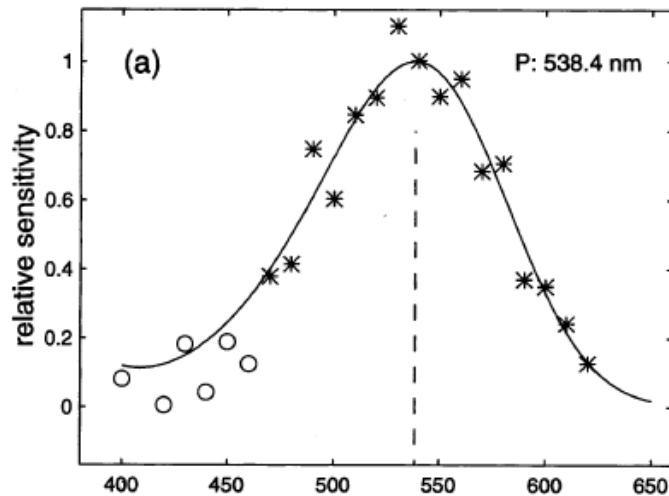
The Cone Visual Pigments of an Australian Marsupial, the Tammar Wallaby (*Macropus eugenii*): Sequence, Spectral Tuning, and Evolution DOI: 10.1093/molbev/msg181

Functional output: electrical signals and behaviour

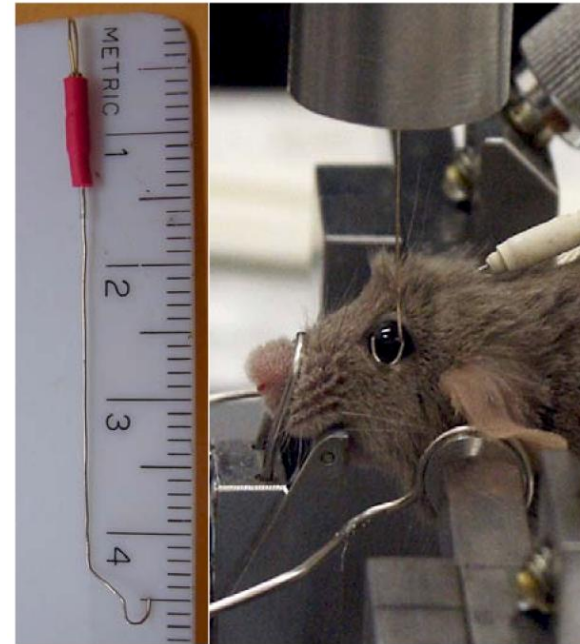
- **Does the retina send an electrical signal to the brain in response to specific wavelengths?**
- **Can the animal perform a behaviour that demonstrates discrimination between colours?**
- **Is the colour relevant in the animal's environment?**

Dichromats

Tammar wallaby

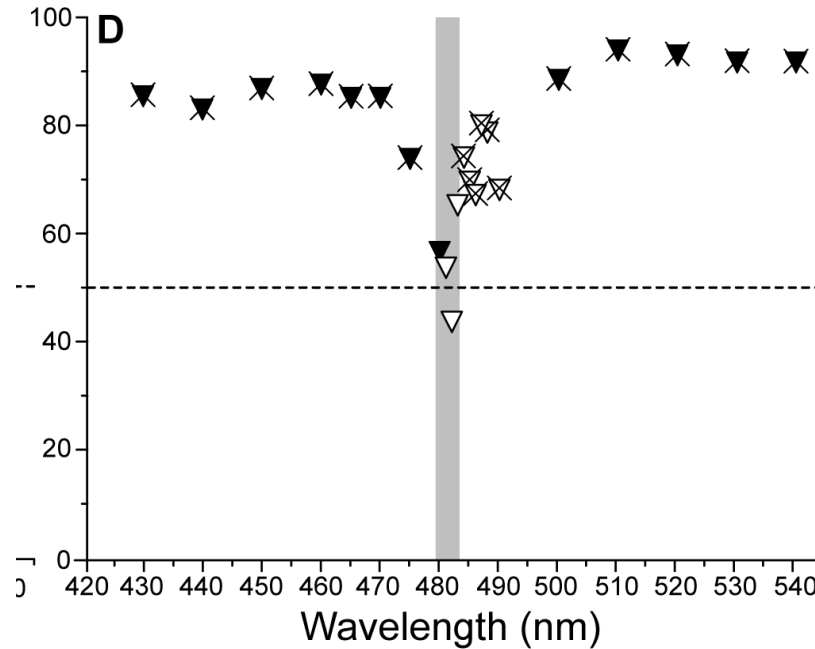


Electroretinogram



doi: 10.1016/s0042-6989(99)00210-2. Spectral sensitivity of photoreceptors in an Australian marsupial, the tammar wallaby (*Macropus eugenii*)

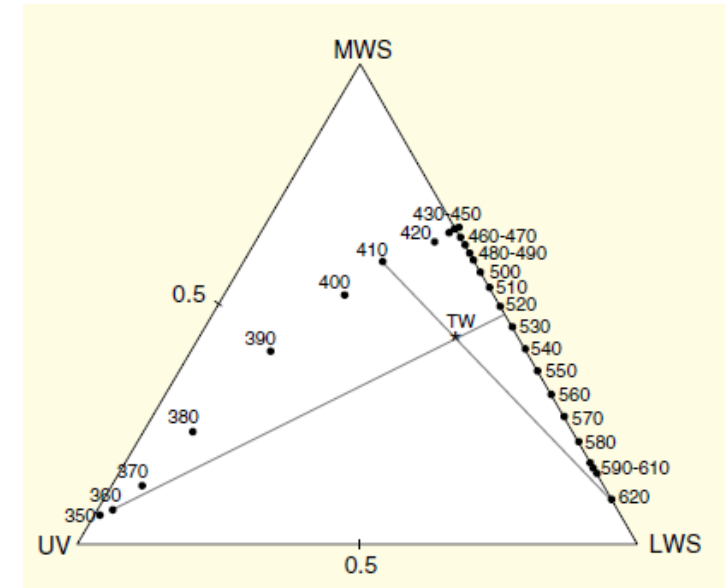
Dichromats!



Colour discrimination over an extended wavelength range of 430 nm–540 nm where choice of the colour stimuli was rewarded over white. Responses show that monochromatic lights could be discriminated from white light for both short and long wavelength colours ($n = 1439$), but not for colours around 483 nm–485 nm.

Dichromatic colour vision in an Australian marsupial, the tammar wallaby. *J Comp Physiol A* **185**, 509–515 (1999).
<https://doi.org/10.1007/s003590050411>

Trichromats!

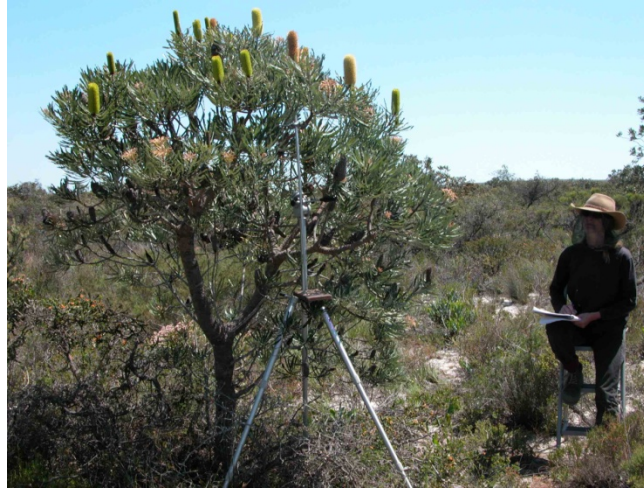


Behavioural evidence for marsupial trichromacy <https://doi.org/10.1016/j.cub.2006.02.036>

Trichromats!



Use of colour vision: honey possum



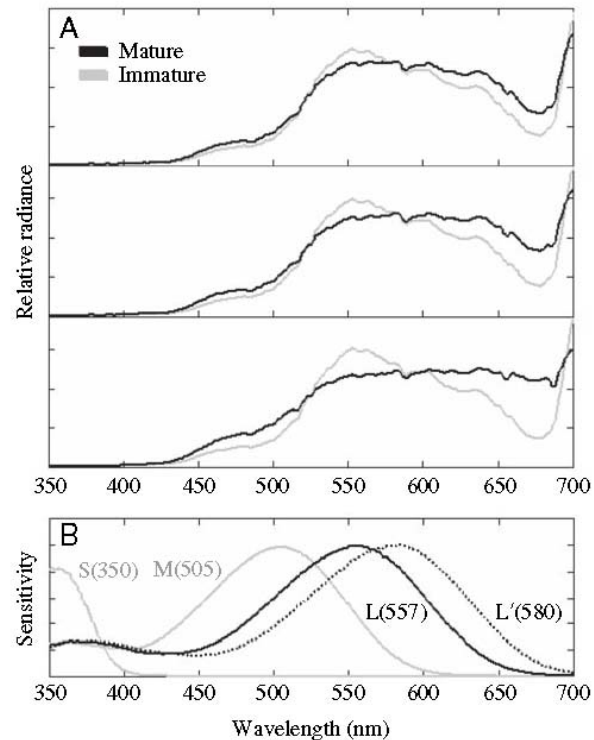
🐭 spectroradiometry: measure reflectance of visual target



Use of colour vision: honey possum

optimal for critical discrimination of flower maturity

1810 P. Sumner, C. A. Arrese and J. C. Partridge

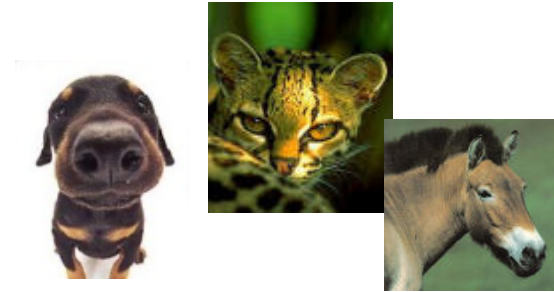


The ecology of visual pigment tuning in an Australian marsupial: The honey possum *Tarsipes rostratus*
DOI:10.1242/jeb.01610

The story so far...



SWS1 SWS2 MWS LWS



SWS1 ~~SWS2~~ ~~MWS~~ M/LWS



SWS1 ~~SWS2~~ ~~MWS~~ M/LWS ↔ M/LWS



SWS1 ~~SWS2~~ [?]MWS LWS



Dichromacy vs Trichromacy in marsupials: or both?

- **reptilian retinal features (double cones, oil droplets, cone dimensions, rod:cone ratio)**
- **ecological diversity (diurnal, arhythmic, crepuscular, nocturnal)**

doi: 10.1371/journal.pone.0014231 Diversity of Color Vision: Not All Australian Marsupials Are Trichromatic

What should you know from this lecture?

Different methods of studying colour vision

Controversy over marsupial colour vision